BAGHOUSE FINES AND DUST CONTROL OPTIONS

By J. Don Brock, PhD., P.E.
Revised by Jonathan Brown and Greg Fricks
# Technical Paper T-121

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INTRODUCTION

Aggregates used to produce hot and warm mix asphalt contain varying gradations of material, ranging in size from one and one-half inch down to less than one micron, a ratio of 38,000 to one. Some of the finer particles become airborne during the drying process and are collected in various types of collection systems. As air pollution requirements became more stringent in the mid-1970s, dry fabric filter dust collector baghouses became the prevalent collector used on asphalt facilities.

The fine dust particles collected in these devices are commonly referred to as baghouse fines. Baghouse fines are not foreign ingredients used in the mix, but merely the finer fraction of the aggregate being processed.

The size of the particles collected in the baghouse is determined by three factors:

1. The actual gradation of the original material being processed
2. The sequence of collectors used to collect the dust before the baghouse
3. The amount of degradation of material through the process

MIX DESIGN

An integral part of mix design is determining the proper dust-to-asphalt ratio. Similarly, an integral part of mix production is the proper handling and control of dust throughout the process. Because 25-50% of the dust that is fed into the dryer can become entrained into the gas stream and captured by dust collection equipment, the method by which dust is accounted and controlled is very important, since the final mix gradation can quickly move out of specification. Knowing how to reintroduce the proper amount of this dust back into the production cycle will ensure that the mix produced continues to stay within specifications, with the least amount of equipment and labor costs.

NAPA found that such dust, generally less than 15 microns in size, could virtually replace asphalt, but if used in excess, was detrimental and would stiffen the asphalt mix considerably. Accordingly, NAPA recommended a specific ratio of dust to asphalt. A ratio by mass of 1 part dust (up to 1.2 parts dust) smaller than 15 microns to 1 part liquid asphalt was recommended.

Specifying agencies have adopted this dust to asphalt ratio and have now included it in many specifications. They broadly refer to material smaller than 200 mesh without designating its specific makeup. This is in error. More than 1 part of dust can be satisfactorily used, depending on

EFFECTS OF DUST IN THE MIX

Before air pollution laws changed, a minimum amount of the material smaller than 200 mesh was returned to the mix. In the early 1980s, NAPA’s Quality Improvement Committee conducted an exhaustive study on using baghouse fines in asphalt mix to learn whether they were detrimental or beneficial.

The study found that adding dust particles smaller than the film thickness of the asphalt to the mix was beneficial. The dust particles extended the asphalt, allowing use of less liquid asphalt.

Excessive Dust

- Increases surface area, decreases film thickness and durability
- Increases AC requirement
- Can become part of the asphalt causing hardening

Insufficient Dust

- Decreases surface area, increases film thickness and results in tender mix
- Results in higher air voids, increasing oxidation and moisture problems
the makeup of dust smaller than 200 mesh (75 microns). But if the dust contains substantially high percentages of particles smaller than 15 microns, the 1 to 1 ratio is correct. For a fuller explanation of this study please refer to NAPA’s QIP 102.

MIX DESIGN

Each mix design starts with a specification with minimum and maximum limits for each gradation size (Figure 1). Gradation limits help ensure that the mix gradation is maintained so that desired performance properties are achieved.

Using currently available aggregates, the contractor determines a Job Mix Formula (JMF) with upper and lower tolerances for use on the project (Figure 2). The JMF is the blend of aggregates best suited to achieve an actual mix gradation that falls within the gradation limits of the mix design.

Tolerances provide a mechanism by which the JMF may be monitored and controlled to consistently provide the desired mix design within minimum and maximum limits for each gradation size.

Aggregate supplies that contain too much dust can cause the final mix to go out of specification by exceeding the maximum allowable dust levels. For aggregate supplies that contain too little dust, or in instances where too much dust is removed, the final mix will be out of specification for too little dust.

DUST CARRYOUT

To ensure that the liquid asphalt will adhere to the dust particles, the aggregate must be dried and heated to the desired mix temperature. To accomplish the drying process, the aggregate is fed into a rotating drum where it is picked up and cascaded through a stream of hot gases. The size of the dust particles that become airborne vary depending on the velocity of gases in the drum (drum gas velocity) as well as the design of the AC injection point.

Typical aggregate dryers (Figure 3), such as those found on batch plants, have a drum gas velocity limit of approximately 800 to 1,000 feet per minute.
For early parallel flow drum mixers (Figure 4), liquid asphalt cement is injected downstream in the drum so that the mixing occurs away from the drying section. Less dust is carried out by the gas stream because the asphalt causes the dust to adhere to the aggregate. With this design, drum gas velocities were increased to approximately 1,000 feet per minute.

A drum with a coater or mixer at its discharge end (Figure 5) has design gas stream velocities of approximately 1,000 feet per minute and higher. Dust carryout occurs because the asphalt cement is not injected directly into the drum. However, the large dropout area above the coater causes larger airborne dust particles to fall out of the airstream and into the coater.

A counter flow drum mixer with an embedded burner (Figure 6) operates at similar drum gas velocities as the counter flow dryer.

The Double Barrel® mixer (Figure 7) incorporates a counter flow dryer comparable to that shown in Figure 6 and has drum gas velocities of approximately 1,000 feet per minute.

As aggregate travels through a dryer, dust particles of various sizes are picked up by the gas stream. The gas velocity at which these particles become airborne is called the terminal velocity. The larger the particle, the higher the gas velocity required to make it become airborne.
Draft controls have been installed on plants (Figure 8) to make them more energy efficient. These systems sense the suction at the front of the drum, adjacent to the burner. The controls open or close a damper or change the speed of a Variable Frequency Drive (VFD) on the exhaust fan to maintain a slight negative constant pressure or suction at the burner. The drum gas velocities of 800 and 1,000 feet per minute mentioned above are typically the maximum velocities for which plants are designed and correspond to plants’ maximum production capacity.

COLLECTION EQUIPMENT

The coarse fines, typically above 200 mesh (75 μm), are controlled independently of smaller fines (Figure 9). The ability to independently control particles smaller than 200 mesh gives significant flexibility to the operator in order to meet the dust gradation requirements.

Coarse fines from the primary collector, such as a cyclone or inertial separator, fall into a collecting hopper. After passing through a discharge point seal, the coarse fines are picked up by an inclined screw conveyor and returned to the drum or mixer.

Fine dust is collected on the outside of aramid bags, dropped into the hopper section and then removed from the baghouse by a screw auger. From there, these fines can be wasted, stored, or returned to the mixer. If a portion (0 to 100%) of these fines is to be wasted, they are conveyed by another screw conveyor to a truck or collection point for waste. Portions not wasted are returned to the mixer together with the coarse fines. A silo can be used to store the fines, instead of being wasted.
The size of dust particles leaving the drum ranges from 30 mesh down to less than one micron. For comparison, human hair is approximately 100 microns in diameter; 200 mesh material is 75 microns; and cigarette smoke is 0.3 micron.

**PRIMARY COLLECTORS**

**Inertial Separator:** An inertial separator (Figure 10) mounted at the baghouse inlet removes the majority of dust from the airstream prior to the filter bags.

Inertial separators depend on rapid changes in both gas stream velocity and flow direction to remove coarse particles from the air stream.

**Cyclones:** A cyclone (Figure 11) is configured to produce a cyclonic air flow pattern. The centrifugal force causes the dust to move to the outside of the cyclone. The dust then slides down the wall of the cyclone to the hopper. These devices are very efficient in removing larger particles, but their efficiency drops significantly for particles sizes below 30 microns or 400 mesh.

**Multicone:** Figure 12 shows a multicone dust collector using a series of small cyclones. Its efficiency is higher than the single cyclone described above. This type of collector collects much smaller particles than a single cyclone.

**Wet Scrubber:** Although baghouses have replaced them, higher pressure venturi scrubbers, as shown in figure 13, can be used to collect even finer particles than those collected by the low pressure cyclone washer. But they require considerable horsepower to overcome their high pressure drops.
BAGHOUSES

When using a baghouse collector, dust is collected on the outer surfaces of filter bags. The bags are automatically cleaned at regular intervals by forced air (Figure 14) causing them to expand and break free the dust caked on their outer surfaces.

The bags are normally constructed of aramid fibers which are felted onto a scrim. The felt is then made into a sock-type bag. Each bag fits over a wire cage for support. The bags and cages fit into a tube sheet, which is the top wall of the baghouse.

Reverse Air and Reverse Pulse: Reverse air and reverse pulse baghouses are separated into different compartments. Separating the filter rows into different compartments allows for continuous operation even while cleaning.

Reverse Air: In reverse air baghouses, exhaust airflow is stopped in the compartment to be cleaned by a damper and the reverse air fan forces clean air back through the filters.

Reverse Pulse: The patented Dillman Reverse Pulse process utilizes a rotating nozzle assembly (Figure 15) with timed indexing and fast acting air doors. After aligning the nozzle to isolate a single row of bags, the air door quickly opens, providing a pulse of air, dislodging the dust from the bags. Then the air door is closed, which keeps the row off line, allowing the dislodged dust to fall away from the bags. A dedicated air compressor or separate reverse air fan is not required, because the exhaust fan provides the air for cleaning.

Pulse Jet: The pulse jet cleaning system (Figure 16) directs a burst of compressed air through a blowpipe into the top of a row of bags. As the compressed air passes through the venturi, at the top of the bag cage, process air is induced into the bag. The combination of process air and induced air "pop" the dust off of the bags. Each pulse is controlled by the timed opening and closing of solenoid valves. One blowpipe is positioned above each row of bags and typically two rows of bags are cleaned simultaneously. Bags are not taken offline for the cleaning process.

DRYER DUST COLLECTING SYSTEMS - COMPONENTS

Baghouse Discharge Points: Various types of devices (Figures 17 to 20) are used at discharge points to facilitate the movement of dust from the baghouse back to the system, to either be stored or wasted. The rotary airlock or motorized tipping valves are generally used when returning the dust into a continuously pneumatic return system using higher suction.

Surge and Weigh Pots: Surge and weigh pots are optional equipment that are added based on operator preference or state specifications. They help maintain a greater level of control over the final mix.

†See Astec Technical Paper T-139 "Baghouse Applications" for further information.
Surge Pots: Surge pots funnel the fine dust into a rotary airlock which meters the dust through the system. As the amount of dust leaving the baghouse varies (either through cleaning cycles or variations in aggregate sources), the surge pot serves to provide for an even, continuous flow of dust. The speed of the airlock can be adjusted either manually or automatically.

Weigh Pots: As dust enters the weigh pot, the control system monitors the weight of the dust via load cells. This allows the operator to know exactly how much fine material is flowing through the system. When the set point is achieved, a butterfly valve opens, moving the fines through the system.

DUST RETURN LOCATIONS
There are many different locations for returning dust back to the system, depending on the plant type, level of control needed, operator preferences or local specifications.

Batch Tower Bin 1: Dust can be conveyed to the bucket elevator by a dust screw (Figure 21). However, the fine materials will not spread
across the screens but will drop directly through all of the screens and collect along one wall of the first bin, remaining segregated from the rest of the material. A solution is a carrier pan that centers the dust in bin 1 (Figure 22).

**Batch Tower Mixer:** When using a storage bin or silo on a batch tower, the dust can be conveyed directly to the weigh batcher with a screw conveyor (Figure 23). A screw conveyor is more accurate than weighing a small quantity of dust in a large weigh hopper using a scale designed for large quantities. If the dust silo has a weigh pot (Figure 24), the dust can be accurately weighed before it is transferred into the weigh batcher.

**Continuous Mix Facilities:** When returning dust in continuous mix plants, care must be taken to ensure the dust isn’t entrained in the airstream.

For parallel flow drums (Figure 25), the dust can enter through a receiver that uses an impinging cone. The liquid asphalt also enters through the receiver, helping to capture the dust.

On counterflow dryers (Figure 26), the dust enters into the mixing section downstream of the burner. Since this area has low gas velocities, the dust is not picked up by the airstream.

The mixing chamber on the Double Barrel® (Figure 27) also has low gas velocities, which prevents entrainment of the dust.
The specifications set the AC and dust requirements for the mix design. A typical requirement for AC content is 5% of final mix, with tolerances +/- 0.5%. The fine dust content (sieve size 200) requirement is typically 4-6% passing by weight, with tolerances approximately +/- 2%.

Though it is possible to remove significant quantities of dust via washing (wet process) and high frequency screening (dry process), each adds to the per ton mix cost. The wet process in particular, adds water to the feed aggregate that will result in higher drying cost and may have other impact on the production process. For this reason it is desirable to use available aggregate and manage fines content in the feed material by balancing the job mix formula to minimize or eliminate the need to waste dust. Furthermore, minimizing virgin material dust content allows for a greater dust contribution from RAP if used. Since fine RAP has higher liquid content due to its large surface area, use of fine RAP is preferable to reduce virgin binder content in as much as the resultant binder grade will allow.

As the aggregate travels up the conveyor, a weigh bridge measures all of the aggregate flowing into the drum (measured in tons per hour) and labeled $A_{TPH}$ (Figure 28). This value includes coarse and fine dust. The controller accounts for slight variations in the aggregate flow rate and adjusts the AC flow rate accordingly, to maintain the appropriate AC content.

If any dust is removed ($DO_{TPH}$), then the total amount of aggregate entering the drum is reduced ($A_{TPH} - DO_{TPH} = AD_{TPH}$) (Figure 29). However, if the dust is not measured, the control system will use the last known flow rate as measured at the weigh bridge for AC flow rate control. This will result in AC content being different from actual AC content.

If no method of weighing dust is installed, then AC and dust flow rates (removed or added) are set by manual trial and error adjustments. AC flow rates entered into the control system could be artificially higher or lower than the Job Mix Formula level, based on the predicted results of the tests. This leads to a discrepancy between what the control system and test results show as the resulting AC content.

For complete and automated control (Figure 30), the dust must be weighed both as it is removed and added back into the process flow, $DO_{TPH}$ and $DI_{TPH}$, respectively. This ensures that the aggregate going to the drum is known.

The weigh bridge measures all of the aggregate flowing into the process and Weigh Pot 1 measures all of the dust removed, relaying this information to the controller. Using the Job Mix Formula, the controller calculates the amount of dust needed to be returned to the system and the amount of AC needed.

$$A_{TPH} - DO_{TPH} + DI_{TPH} = AD_{TPH}$$

With slight variations in the amount of total aggregate ($A_{TPH}$) and dust removed ($DO_{TPH}$), the controller makes the needed adjustments.
in the amount of dust returned and AC injected, reducing the need for extra tests for trial and error adjustments.

In recent years, there is a growing trend for regulating authorities to impose specifications and constraints as well as documentation requirements further upstream in the HMA/WMA production process. The intent of these actions is to help ensure final mix quality and to help prevent the significant impact of producing and placing mix that does not meet specifications. The rationale is that monitoring and controlling the production process further upstream minimizes the potential downstream effect. Automatic control is the only system that accounts for all dust in the feed materials and adjusts AC flow rate accordingly.

Since aggregate sources, aggregate quality, and regulations may change over time, it is important to maintain process flexibility. Though automatic control of dust may not currently be necessary in any particular locale, it may become necessary in the future. Configuring dust systems to at least be ready for automatic control as conditions warrant is a wise equipment choice. Configurations may be designed to minimize initial capital outlay based upon current need while making provision for additional equipment should future need arise.

For all systems configured to waste dust, it is important to remember that an aggregate dryer is not a classifier. Though the process of drying aggregate tends to liberate dust from the aggregate, the amount that can be removed cannot be predicted with any certainty. Aggregate consistency and composition, moisture content, clay content, particle shape, and possibly other aggregate characteristics significantly affect dust carryout. If dust carryout does not sufficiently reduce dust content, then cold feed material (RAP and/or virgin aggregate) dust content must be reduced prior to the drying process by balancing materials, using alternative materials, or removing dust using wet or dry technologies.
Option 1 - Total Control

Only system that accounts for all dust in system to automatically calculate required AC content

**Operation**
- Constant volume vane feeder returns all coarse dust to drum
- Constant volume vane feeder returns all fine dust to weigh pot
- Fine dust removed is weighed and sent to surge pot
- Blower returns all dust to silo for storage until being returned or wasted
- Fine dust is metered using a mass flow weigh pot utilizing an automatically adjusted VFD air lock

**Advantages**
- Weighing of fine dust leaving baghouse provides amount of fine dust needed for return
- AC flow is automatically adjusted based on measured change in fine dust component
- More dust can be added than is removed, if needed, because of silo
- Ensures steady dust flow from baghouse at start up and mix design transitions

**Disadvantages**
- Highest cost
- Highest maintenance

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Option 2 - Split Return with Weigh Pot

**Operation**
- Constant volume vane feeder returns all coarse dust to drum
- Constant volume vane feeder moves all fine dust out of baghouse
- Blower returns all dust to silo for storage until being returned or wasted
- Fine dust is metered using a mass flow weigh pot utilizing an automatically adjusted VFD air lock
- Dust is wasted as needed based on amount in silo

**Advantages**
- Allows for wasting of dust if aggregate blend cannot meet spec
- More dust can be added than is removed, if needed, because of silo

**Disadvantages**
- Amount of dust moved to silo is unknown
- Amount of dust to return requires trial and error
- AC flow rate requires trial and error
- Since the fine dust is not metered as it leaves the baghouse, required change of AC flow is unknown
**Option 3 - Split Return**

**Operation**
- Constant volume vane feeder returns all coarse dust to drum
- Manually adjusted VFD vane feeder adjusts flow of fine dust — full range of flow between returning all to drum and wasting all — but does not meter dust flow

**Advantages**
- Allows for wasting of dust if aggregate blend cannot meet spec

**Disadvantages**
- Amount of dust to waste requires trial and error
- Cannot add dust without additional mineral feed system
- AC flow rate requires trial and error
- Since the fine dust is not metered as it leaves the baghouse, required change of AC flow is unknown

**Option 4 - Split Return with Surge Pot**

**Operation**
- Constant volume vane feeder returns all coarse dust to drum
- Constant volume vane feed moves fine dust to surge bin
- Butterfly valve above surge pot closes to waste excess dust when high bindicator senses full surge pot
- Manually adjusted VFD vane feeder below surge pot adjusts flow of fine dust but does not meter dust flow

**Advantages**
- Allows for wasting of dust if aggregate blend cannot meet spec
- Ensures steady dust flow from baghouse at start up and mix design transitions

**Disadvantages**
- Amount of dust to waste is trial and error
- Cannot add dust without additional mineral feed system
- AC flow rate is trial and error
- Since the fine dust is not metered as it leaves the baghouse, required change of AC flow is unknown
**Option 5 - Return All with Surge Pot**

**Operation**
- Single constant volume vane feeder returns all dust to surge pot
- Manually adjusted VFD vane feeder below surge pot returns dust to drum

**Advantages**
- Ensures steady dust flow from baghouse at start up and mix design transitions
- Relatively low cost

**Disadvantages**
- Coarse and fine dust handled together
- Does not control dust in mix beyond cold feed bin controls
- All dust collected will be returned to mix
- Cannot waste dust
- Cannot add dust without additional mineral feed system

**Option 6 - Return All**

**Operation**
- Single constant volume rotary vane feeder returns all dust collected to drum

**Advantages**
- Lowest cost

**Disadvantages**
- Coarse and fine dust handled together
- Does not control dust in mix beyond cold feed bin controls
- All dust collected will be returned to mix
- Cannot waste dust
- Cannot add dust without additional mineral feed system
**Option 1 - Return All**

**Operation**
- Single constant volume rotary vane feeder returns all dust collected to bucket elevator

**Advantages**
- Lowest cost

**Disadvantages**
- Coarse and fine dust handled together
- Does not control dust in mix beyond cold feed bin controls
- All dust collected will be returned to mix
- Cannot waste dust
- Cannot add dust without additional mineral feed system

**Option 2 - Split Return with Auger**

**Operation**
- Constant volume vane feeder returns all coarse dust to elevator
- Constant volume vane feeder moves all fine dust out of baghouse
- Blower returns all dust to silo for storage until being returned or wasted
- Fine dust is metered to mixer using auger
- Dust is wasted as needed based on amount in silo

**Advantages**
- Allows for wasting of dust if aggregate blend cannot meet spec
- More dust can be added than is removed, if needed, because of silo

**Disadvantages**
- Amount of dust moved to silo is unknown
- Higher cost than “return all”
- Higher maintenance than “return all”
Option 3 - Split Return with Weigh Pot

Operation
- Constant volume vane feeder returns all coarse dust to drum
- Constant volume vane feeder moves all fine dust out of baghouse
- Blower returns all dust to silo for storage until being returned or wasted
- Fine dust is metered to mixer using a mass flow weigh pot
- Dust is wasted as needed based on amount in silo

Advantages
- Allows for wasting of dust if aggregate blend cannot meet spec
- More dust can be added than is removed, if needed, because of silo

Disadvantages
- Amount of dust moved to silo is unknown
- Higher cost than “return all”
- Higher maintenance than “return all”

CONCLUSION

Baghouse fines are an integral part of any mix design and should be properly handled and controlled. Understanding how fines move through the system, along with proper measuring and reintroduction methods will allow the operator to produce a consistent, high quality mix.
ASTEC encourages its engineers and executives to author articles that will be of value to members of the hot mix asphalt (HMA) industry. The company also sponsors independent research when appropriate and has coordinated joint authorship between industry competitors. Information is disbursed to any interested party in the form of technical papers. The purpose of the technical papers is to make information available within the HMA industry in order to contribute to the continued improvement process that will benefit the industry.